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REMOVAL SITE EVALUATION WASTE PIT AREA ROADS AND EXPOSED SURFACES ARPIL, 1991

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REMOVAL SITE EVALUATION

Waste Pit Area Roads and Exposed Surfaces

Feed Materials Production Center
U.S. Department of Energy

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1.0 Introduction

This Removal Site Evaluation (RSE) addresses potential problems due to loose surface contamination on roads and shoulders, graded surfaces, water drainage paths, and any re-exposed wastes. **Waste pits 5 and 6 are not included because the pit surfaces are most frequently covered with standing water.** The scope is limited to the Waste Pit Area and does not include the BDN Lagoon, Silos 1-4, and the Sludge Ponds. The extent and nature of contamination was developed through review of data from the Roy F. Weston Characterization Investigation Study (C.I.S.)[1], current RI/FS information, and the FMPC annual Environmental Monitoring Reports.

Figure 1 shows the waste storage area components which were used for disposal of production waste streams at the FMPC. These disposal practices were discontinued in 1986. The WPA is located within the waste storage area in the northwestern portion of the FMPC. The WPA covers approximately 25 flat-lying acres west of the FMPC production area. It is fenced and has always had controlled access.

The WPA is within Operable Unit 1 pursuant to the Federal Facilities Compliance Agreement of 1986 (with subsequent modifications). There is an on-going CERCLA Remedial Investigation and Feasibility Study (RI/FS) for the FMPC that is assessing environmental conditions and possible remedial actions for the components of the WPA.

Table 1 provides a brief description of the waste units comprising OU 1: 6 Waste Pits, a formerly used Burn Pit, and the Clear Well.

This RSE has been completed by the DOE under authorities delegated by Executive Order 12580 under Section 104 of CERCLA and is consistent with Section 300.410 of the National Oil and Hazardous Substance Pollution Contingency Plan (NCP).

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[1]Weston, Roy F., Inc., "Characterization Investigation Study, Vol. 3, Radiological Characterization of Surface Soils in the Waste Storage Area," 1987.

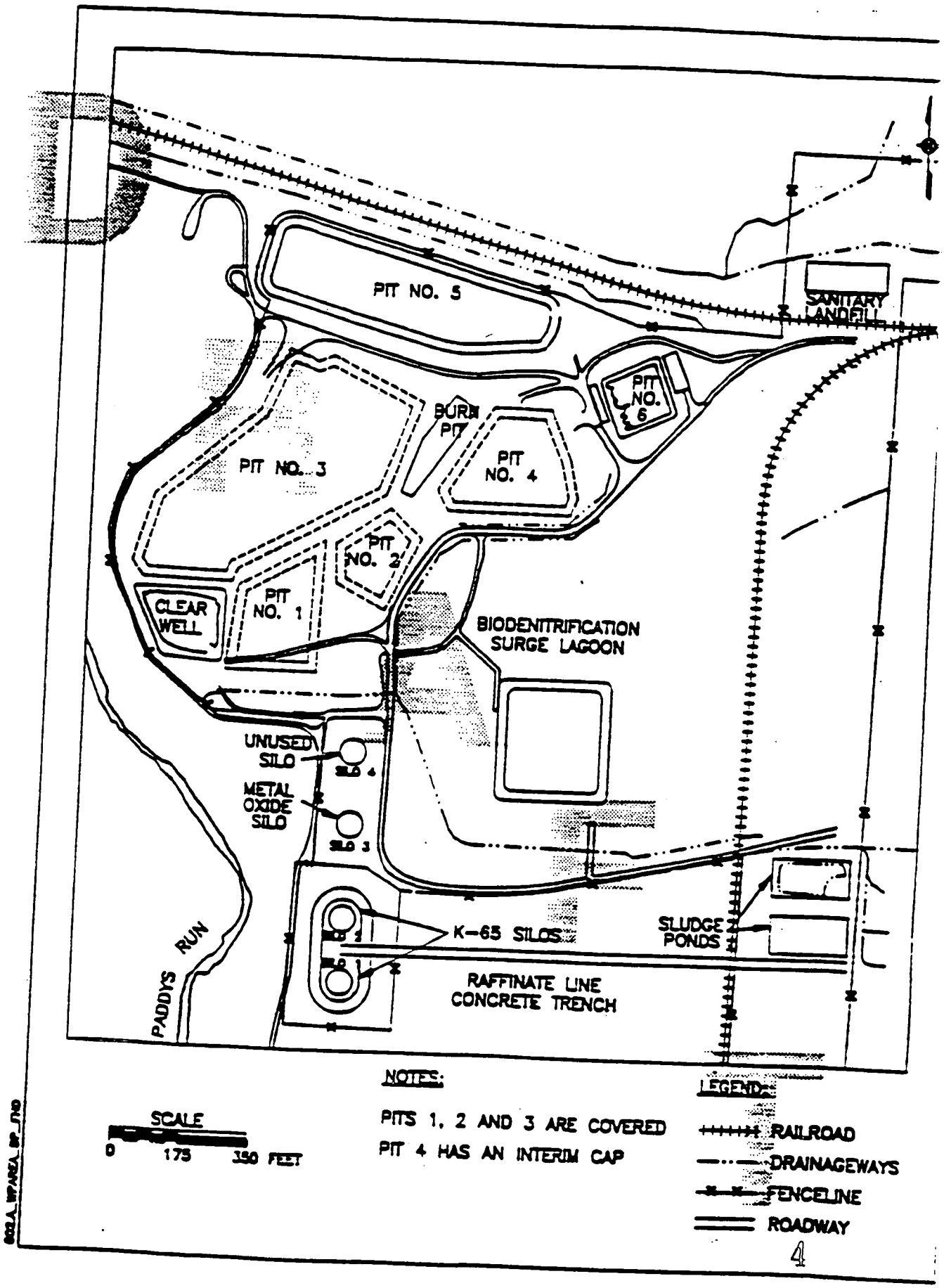

FIGURE 1. WASTE STORAGE AREA

TABLE 1
GENERAL CHARACTERISTICS OF THE WASTE PIT AREA

Waste Pit	Estimated Waste quantity (cu yd)	Depth (ft)	Contents	Estimated Radioactive Material (kg)	Construction	Operational Period	Current Status
Pit No. 1	40,000	17	Neutralized waste filter cakes, graphite, brick scrap, sump liquor and cakes, depleted slag	Uranium - 52,000	Excavated in clay lined and lined with clay	1952-59	Covered with clean fill dirt
Pit No. 2	13,000	13	Dry low-level radioactive wastes: neutralized waste filter cakes, sump liquor and cakes, brick, scrap, depleted slag	Uranium - 1,206,000 Thorium - 400	Lined with a compacted on-site native clay layer	1957-64	Covered with clean fill dirt
Pit No. 3	227,000	27	Lime neutralized raffinate concentrate, slag leach residues, filter cakes, fly ash and lime sludge	Uranium - 129,000 Thorium - 400	Excavated into clay lens and lined with clay along the pit walls	1959-77	Covered with clean fill dirt
Pit No. 4	53,000	24	Process residues, trailer cakes, slurries, raffinates, depleted graphite, asbestos, nonburnable trash, barium chloride	Uranium - 3,000,000 Thorium - 61,800	Same as Pit No. 3	1960-86	Partially covered
Pit No. 5	102,500	30	Solids from neutralized raffinate, slag leach slurry, lime sludge	Uranium - 50,309 Thorium 17,000 kg	Lined with 60 mil Royal-Seal EPDM elastomeric membrane	1968-83	Uncovered
Pit No. 6	9,000	24	Depleted slag, sump green salt, process residue, filter cake	Uranium - 843,142	Same as Pit No. 5	1979-85	Uncovered
Burn Pit	Unknown	Unknown	Reactive chemicals, pyrophoric chemicals, oils, combustible wastes, scrap iron, wood, tin cans, ashes, and gravel	Unknown	Excavated in clay Excavated clay used to line Pits 1 and 2	1957-?	Backfilled
Clear Well	Unknown	Unknown	Clear process effluents and and surface runoff	Unknown	Lined with clay	1959-87	In use

*Source: DOE 1989; Weston 1986a

2.0 Source Term

The ongoing RI/FS is providing an in-depth analysis of the nature and extent of contaminants, the present and potential exposure pathways, and alternatives for final remedial action. This RSE focuses on the surface contamination in the WPA to assess any need for more immediate actions. This analysis considers inhalation exposure from entrained airborne contaminants and, for occupational exposure, direct radiation exposure from surface contamination. **Air monitoring data suggests very limited airborne transport.** The physical and visible characteristics of the area are reviewed along with with data from instrument surveys and analyses of soil, sediment, and air samples.

2.1 Physical and Visible Features

Site inspection, and a review of a recent aerial photograph, shows exposed surfaces which can be compared to data which characterize the nature and magnitude of contamination at those locations. Relatively unfixed soil surfaces include roads and shoulders, and graded areas; traffic and winds could increase airborne contamination concentrations. Other potential problem areas have more stabilized surfaces but still require consideration as a potential contributor to exposure. An example is a bare area at the center of the western half of Waste Pit 3. A concern is that some of the waste pit residues may no longer be covered with clean fill dirt. Surface water drainage pathways were identified in the area as part of the C.I.S. (Figure 2).

2.2 Radiation Instrument Surveys.

Four types of radiation detectors have been used for surveys in the Waste Pit Area as part of the C.I.S. and the RI/FS.

1. FIDLER thin NaI(Tl) gamma scintillator
2. Thin window geiger-mueller pancake detector
3. SPA-3 2x2" NaI(Tl) gamma scintillator
4. Pressurized Ion Chamber

There are a number of factors that complicate correlation of instrument measurements to surface contamination concentrations. However, elevated measurements reveal the presence of contamination. Attention can be directed to sample analyses from the elevated locations.

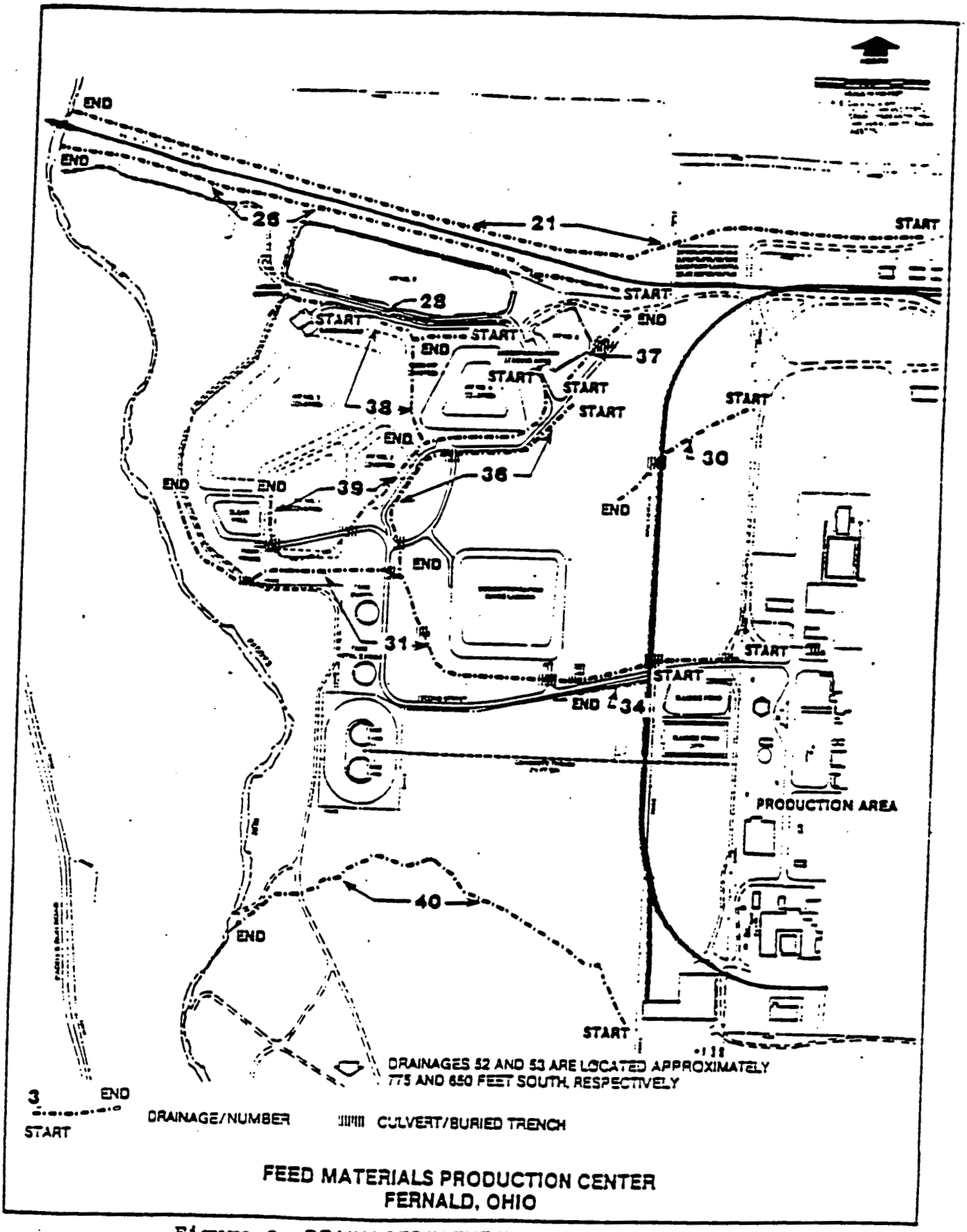

Figure 2 DRAINAGES IN THE WASTE STORAGE AREA

The FIDLER is particularly suited to measure low energy photons and has limited response to higher energy gamma rays that might be present. For these surveys, the FIDLER was optimized to respond to the 63 and 93 kev gamma rays associated with uranium-238 through its daughter thorium-234. Figures 3, and 3 a-c present FIDLER measurement contours established through the C.I.S. survey. The area of greatest concern is evident in Figure 3b and includes Pit 4 and the area between Pits 4 and 6.

The beta-gamma survey used thin window geiger-mueller (g-m) detectors. While sensitive, the detector responds non-specifically to alpha, beta, and gamma rays. Elevated measurements do reveal potential problem areas. Uranium daughters include energetic beta emitters. It is possible that elevated g-m measurements, which did not have corresponding elevated gamma levels, indicate the presence of uranium surface contamination. Beta-gamma dose rate contours from the C.I.S. survey are presented in Figures 4 and 4a-c. An area of concern corresponds to the bare spot in Waste Pit 3. This is shown near the southwest corner of Figure 4a and the northwest corner of Figure 4c.

The isopleths from the more recent instrument surveys, performed as part of the RI/FS, are not yet available. However, a review of the data confirms the C.I.S. information and does not show any new suspect areas.[2] The other two kinds of measurements, with 2x2 inch NaI(Tl) scintillation detectors and pressurized ion chambers, provided the gamma ray measurements at various locations across the pit area, but lacked resolution of contamination contours provided by the FIDLER and g-m surveys. No additional suspect areas could be identified.

2.3 Surface Soils

All the surface soil and sediment sample data from the C.I.S. and RI/FS investigations were reviewed and analyzed. The data were compared to the physical features of the WPA and instrument measurements. The following zones of most significant contamination were identified.

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[2] ASI/IT, "Remedial Investigation Report for Operable Unit 1," FMPC-0106-2, U. S. Department of Energy, 1990 (draft).

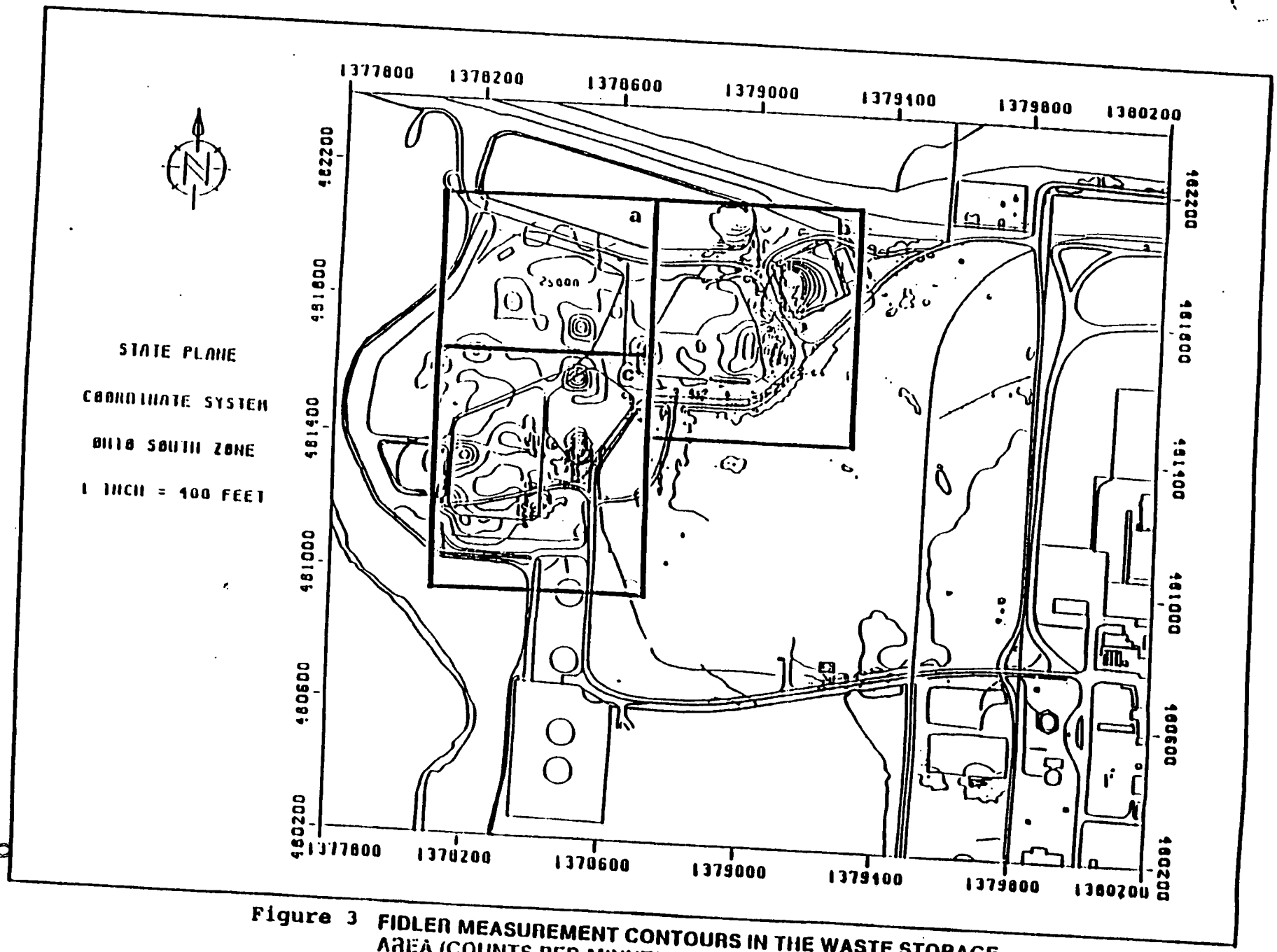

Figure 3 FIDLER MEASUREMENT CONTOURS IN THE WASTE STORAGE AREA (COUNTS PER MINUTE) CONTOUR

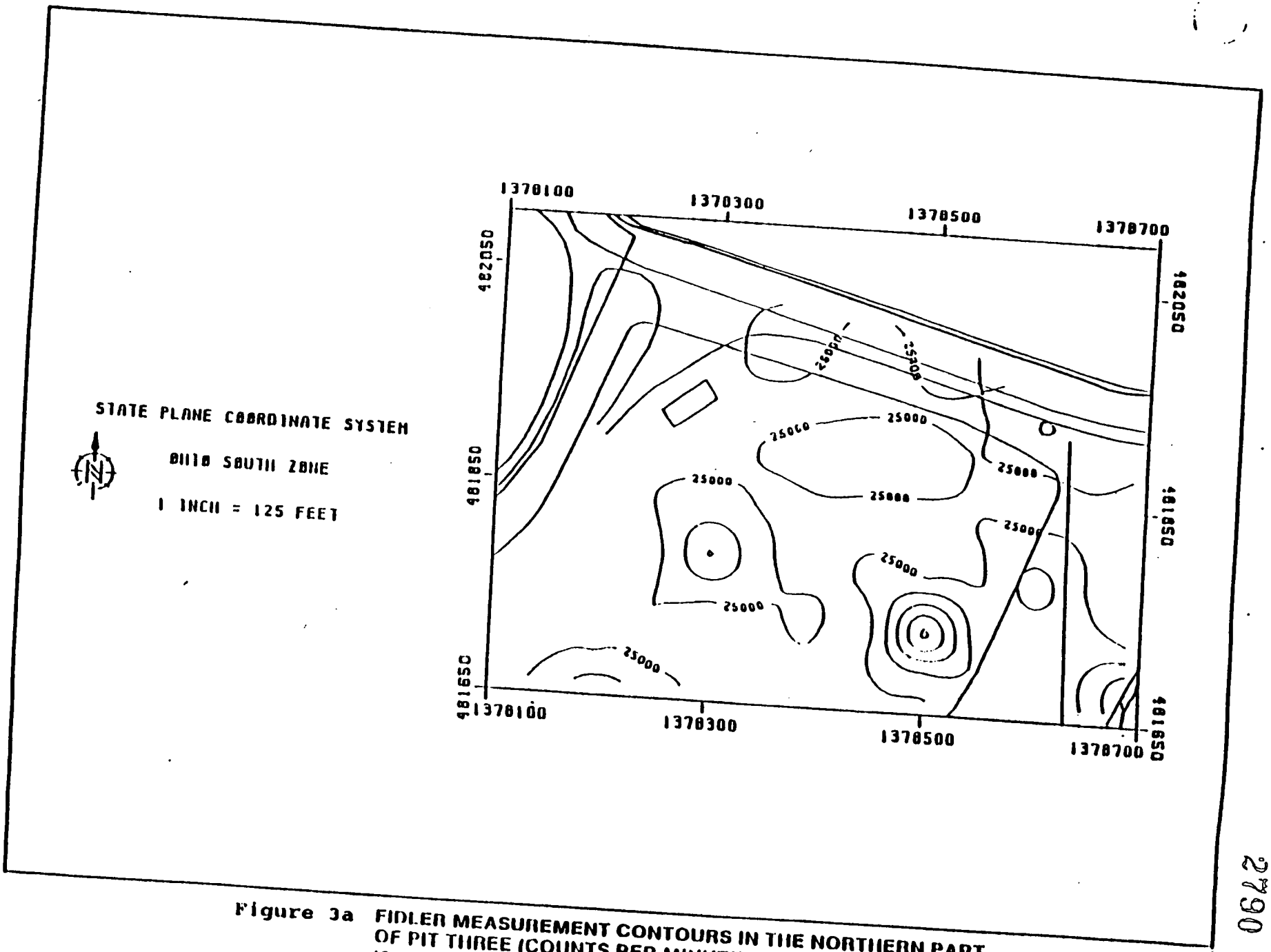

Figure 3a FIDLER MEASUREMENT CONTOURS IN THE NORTHERN PART OF PIT THREE (COUNTS PER MINUTE) CONTOUR INTERVAL IS 50,000 CPM

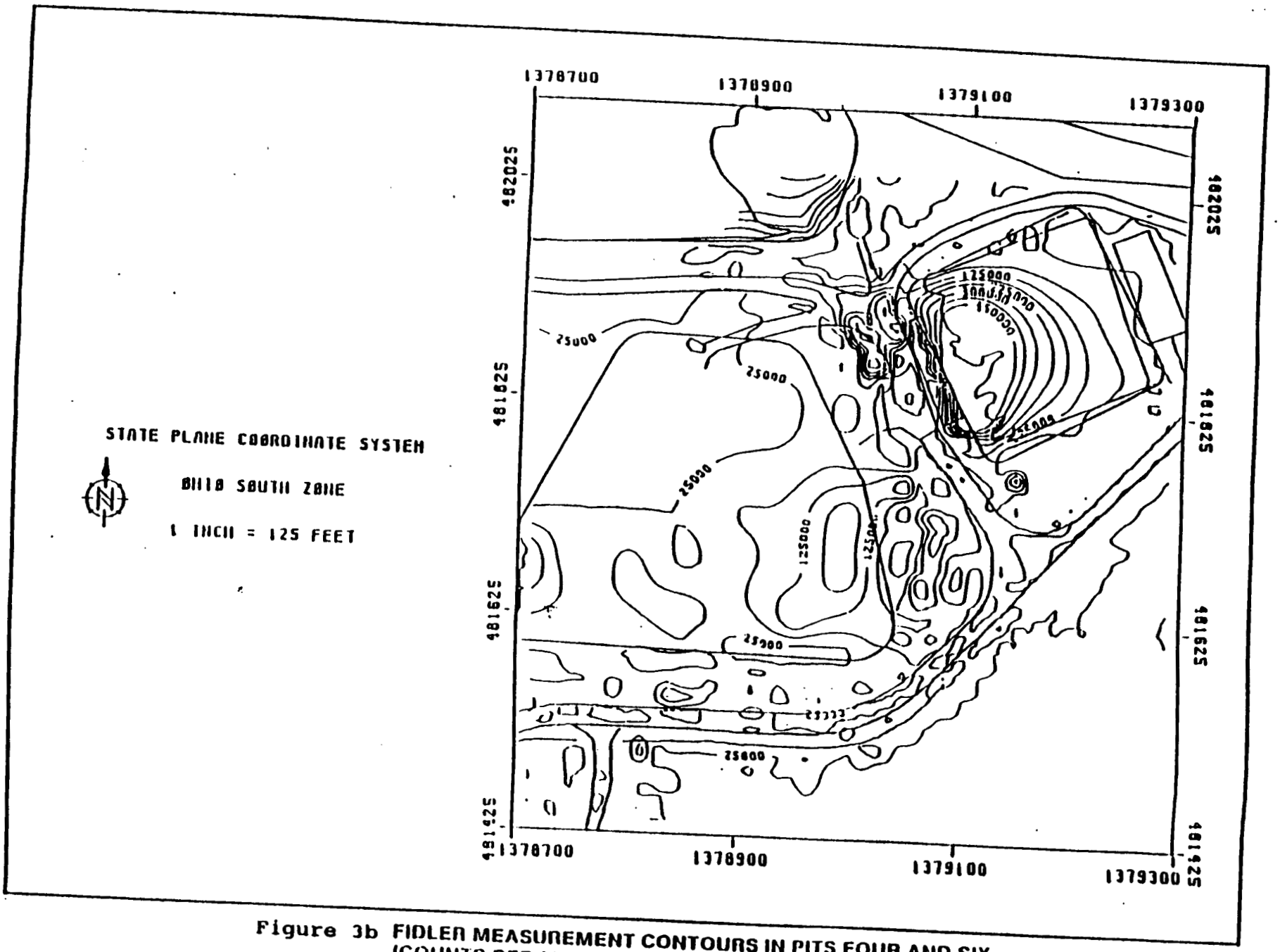

Figure 3b FIDLER MEASUREMENT CONTOURS IN PITS FOUR AND SIX
(COUNTS PER MINUTE) CONTOUR INTERVALS ARE
50,000 AND 75,000 CPM

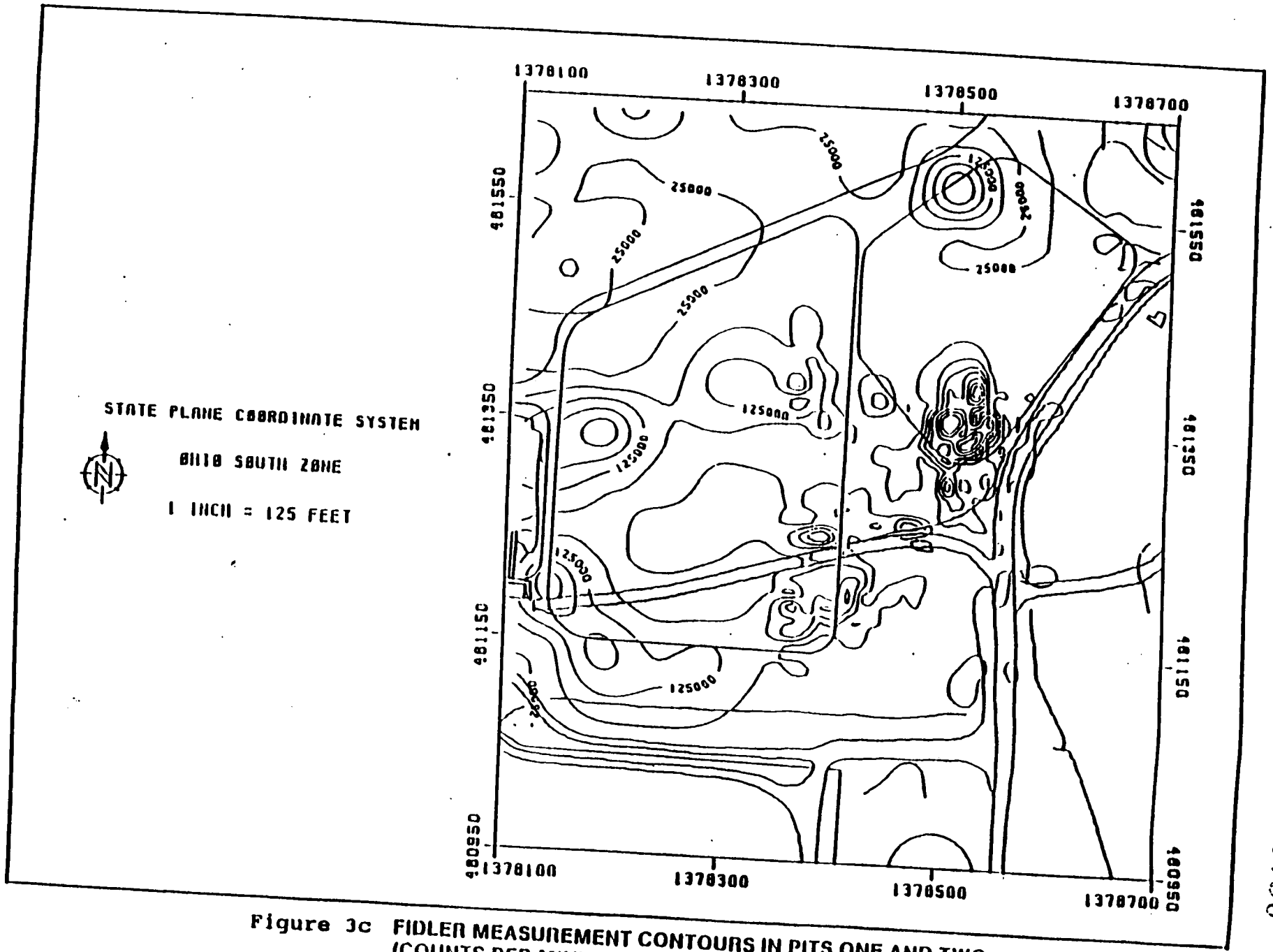

Figure 3c FIDLER MEASUREMENT CONTOURS IN PITS ONE AND TWO
(COUNTS PER MINUTE) CONTOURS

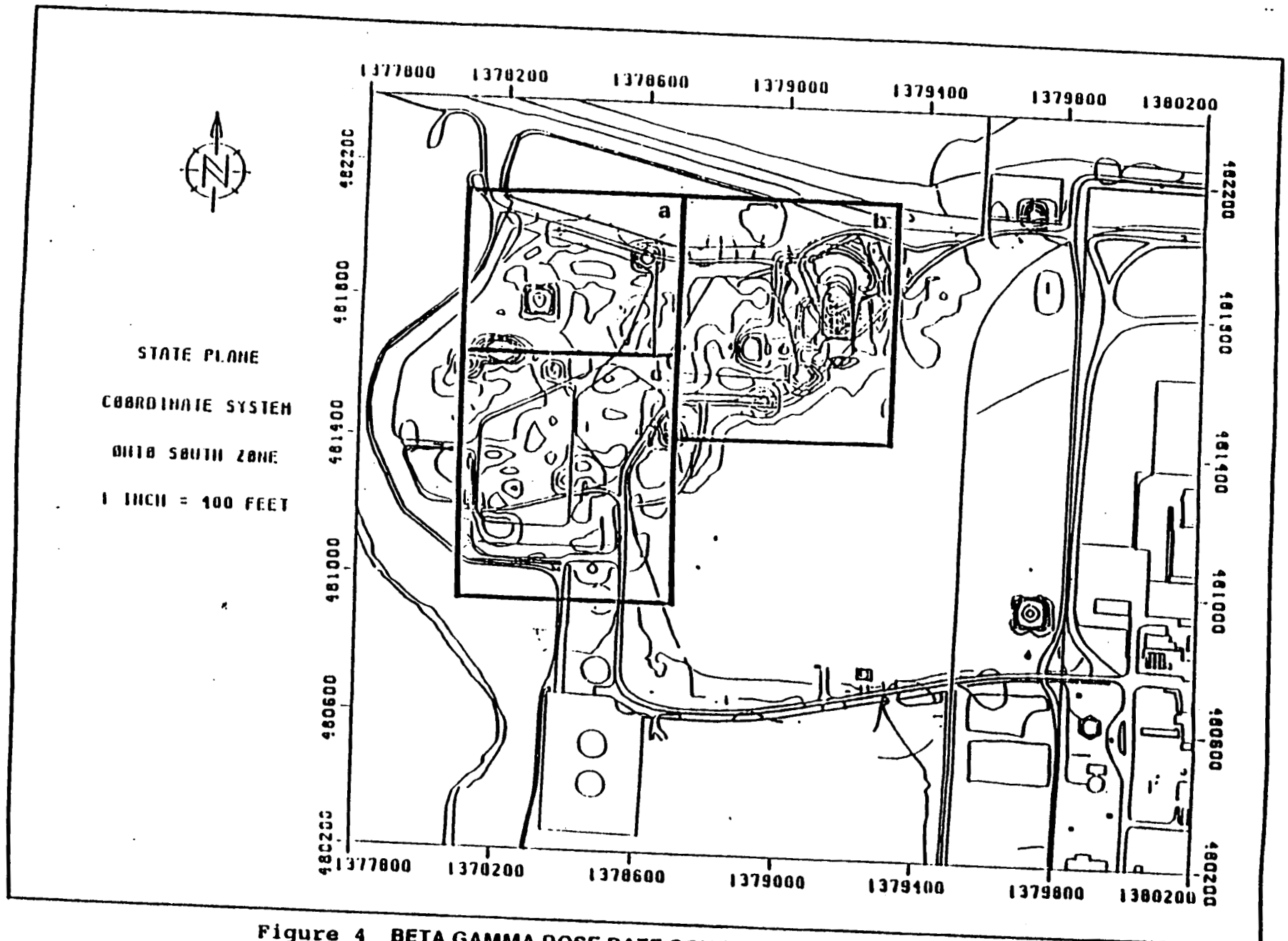

Figure 4 BETA GAMMA DOSE RATE CONTOURS IN THE WASTE STORAGE AREA (mRad/hr) CONTOUR INTERVALS ARE .2, 1.0, AND 5.0 mRad/hr

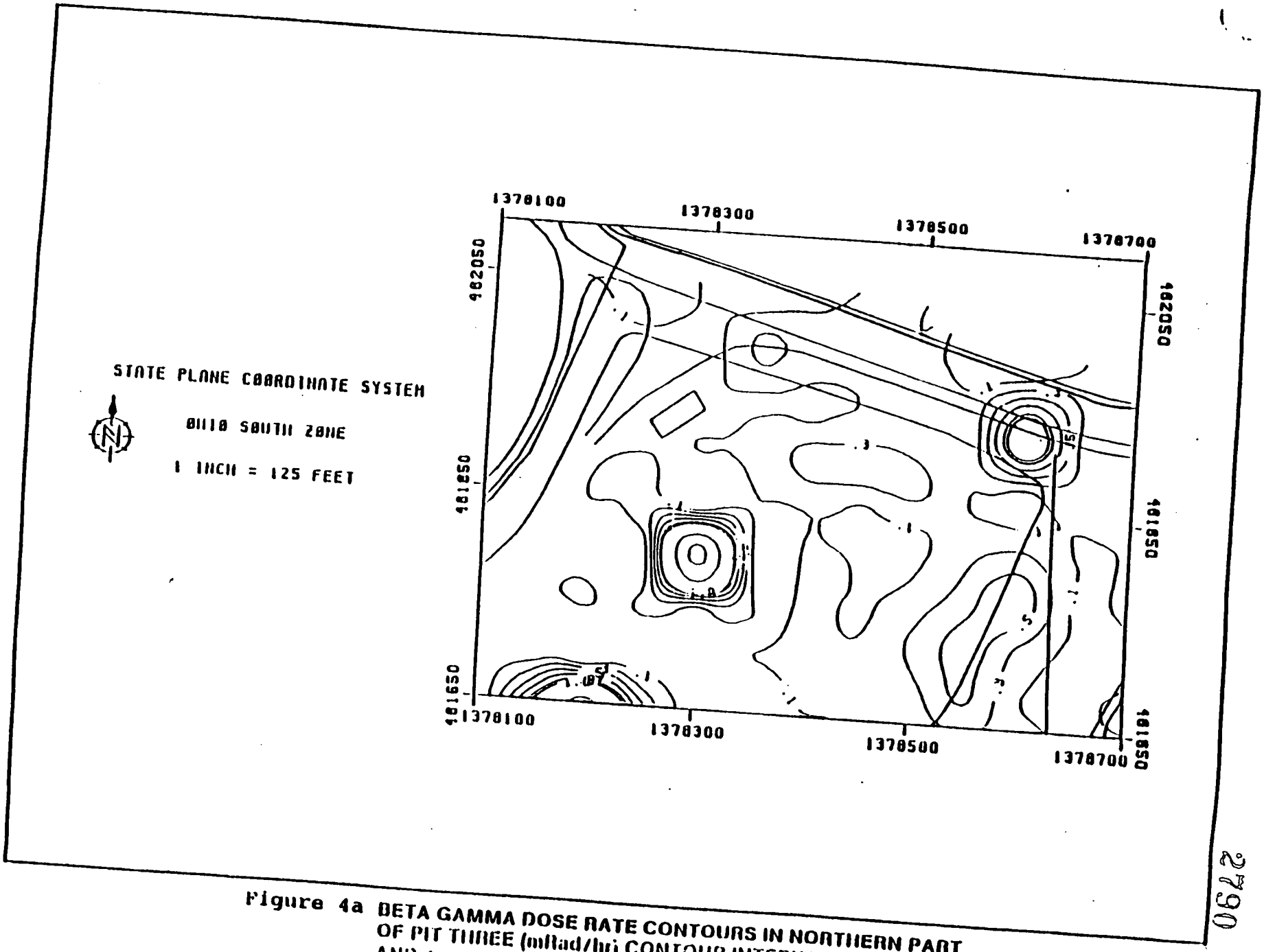

Figure 4a BETA GAMMA DOSE RATE CONTOURS IN NORTHERN PART OF PIT THREE (mRad/hr) CONTOUR INTERVALS ARE 1.0 mRad/hr

Figure 4b BETA GAMMA DOSE RATE CONTO

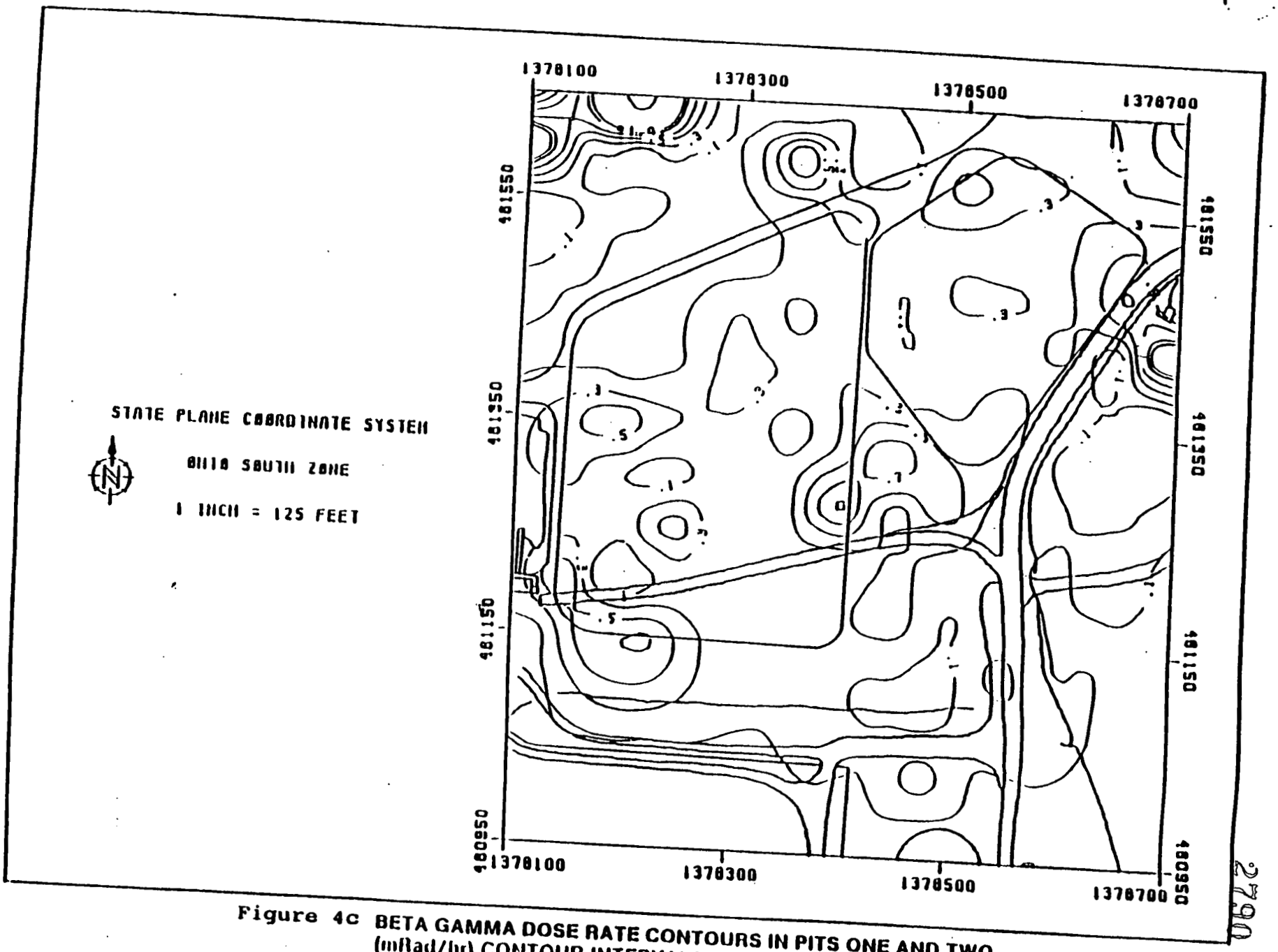

Figure 4c BETA GAMMA DOSE RATE CONTOURS IN PITS ONE AND TWO (mRad/hr) CONTOUR INTERVALS ARE .2 AND 1.0 mRad/hr

1. The immediate area of Waste Pits 4 and 6.
2. An area south and east of Waste Pit 2.
3. An area extending north, east and south of the Pit 4-6 area.
4. The cover of Pit 3.

The cover of Pit 4 also showed elevated levels of uranium. However, a RCRA interim closure cap was completed for this pit in 1989. Therefore, the surface of this pit is no longer considered to be a source of potential uranium contamination.

The first section has the highest and most consistent concentrations. Appendix A.1 summarizes sediment and surface soil concentrations in this area. The average radionuclide concentrations were calculated using soil sample data and sediments data from the drainage to the east of Pit 4 and the drainage south of Pit 5.

Average Sediment and Soil Concentrations
in the Pit 4-6 Area
(pCi/g)

U-238	468±341
U-235	14±11
U-234	89±56
Th-232	2.1±6.6
Th-230	59±212
Th-228	3.4±10.3
Ra-226	4.6±5.4

The principle contaminant is uranium. **The uranium-234 concentrations are considerably lower than those of uranium-238. Most uranium processed at the FMPC was depleted in U-235, and therefore also in U-234. This is not normal or natural uranium.** Most samples had thoriums 232 and 228, and radium-226 near ambient background levels. Sample 46-623 had relatively high thorium-230 (972 pCi/g) as did sample 46-434 (146 pCi/g). These raised the average significantly and also the associated standard deviation.

Appendix A.2 provides concentrations of one sediment sample and five soil samples collected SE of the Pit 2 area. Average concentrations were as follows.

Average Sediment and Soil Concentrations
SE of Pit 2
(pCi/g)

U-238	328±339
U-235	8.5±12.6
U-234	61±55
Th-232	1.0±1.3
Th-230	15±20
Th-228	2.9±4.5
Ra-226	3.9±2.8

Thorium-230 was elevated in samples 46-488 and 46-495; a different source is likely. Thorium and radium-226 were otherwise close to ambient background levels.

The extended area of contamination is generally east of the WPA and can be described as

650 ft. east
250 ft. north and north-northeast
550 ft. south

of a point between Waste Pits 4 and 6. There are 20 surface soil samples (Appendix A.3) that can be used to characterize this region. Averages for this area are listed below.

Average Soil Concentrations
East of the Waste Pit Area
(pCi/g)

U-238	188±204
U-235	4.9±8.0
U-234	40±42
Th-232	3.1±8.8
Th-230	4.2±5.6
Th-228	3.9±8.7
Ra-226	7.1±9.8

Uranium-238 concentrations were variable and ranged from 3.6 to 710 pCi/g.

RI/FS surface soil sampling locations were chosen to supplement C.I.S. data. Those locations are shown on the Figure 5 map. The values in parentheses show uranium-238 concentrations. The relatively low concentrations, compared to those developed above, show that no significant contamination exists at those locations.

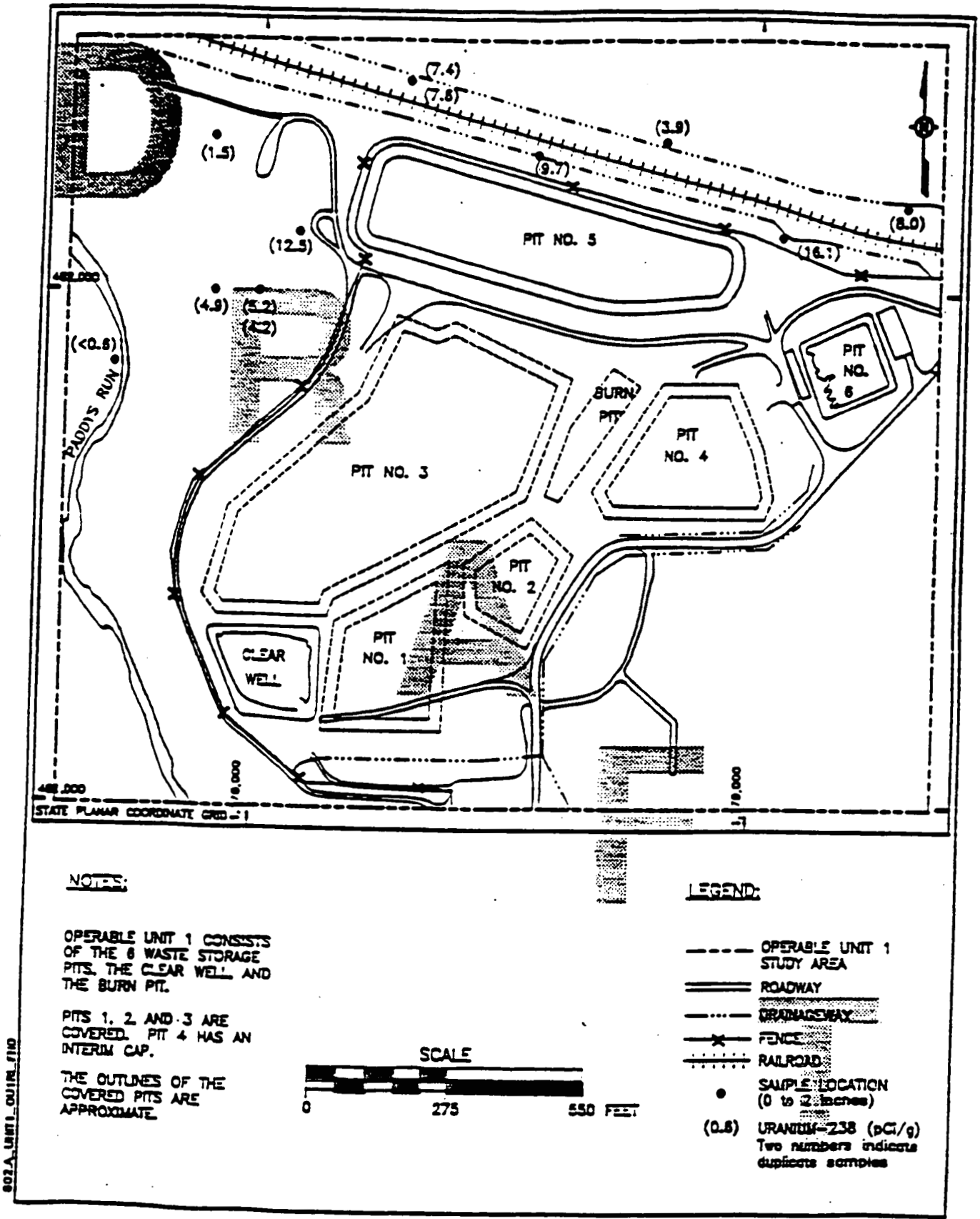

Figure 5 URANIUM—238 CONCENTRATIONS IN pCi/g IN SURFACE SOIL

Six surface soil samples were collected on the cover of Pit 3 during the C.I.S. Uranium was detectable in four of the six and the averages are summarized below.

Pit 3 Cover Soil Samples
(pCi/g)

U-238	410±287
Th-232	<2.3±1.0
Ra-226	<2.2±0.9

All other soil and sediment data used in this RSE are from radiochemical analyses which included sample dissolution and chemical separation. Samples from the Pit 3 cover was analyzed by on-site gamma spectrometry. Results are less direct because gamma emitting daughters were quantitated to infer parent concentrations. Optimum sample preparation, including drying and ball-milling, was not afforded in the field.

During the placement of RI/FS wells in the WPA, soil samples from 0 to 1.5 ft. deep, from four well locations, were analyzed. The highest concentration was from Location 1083 at the southeastern edge of Pit 6 with 32 pCi/g of uranium-238.

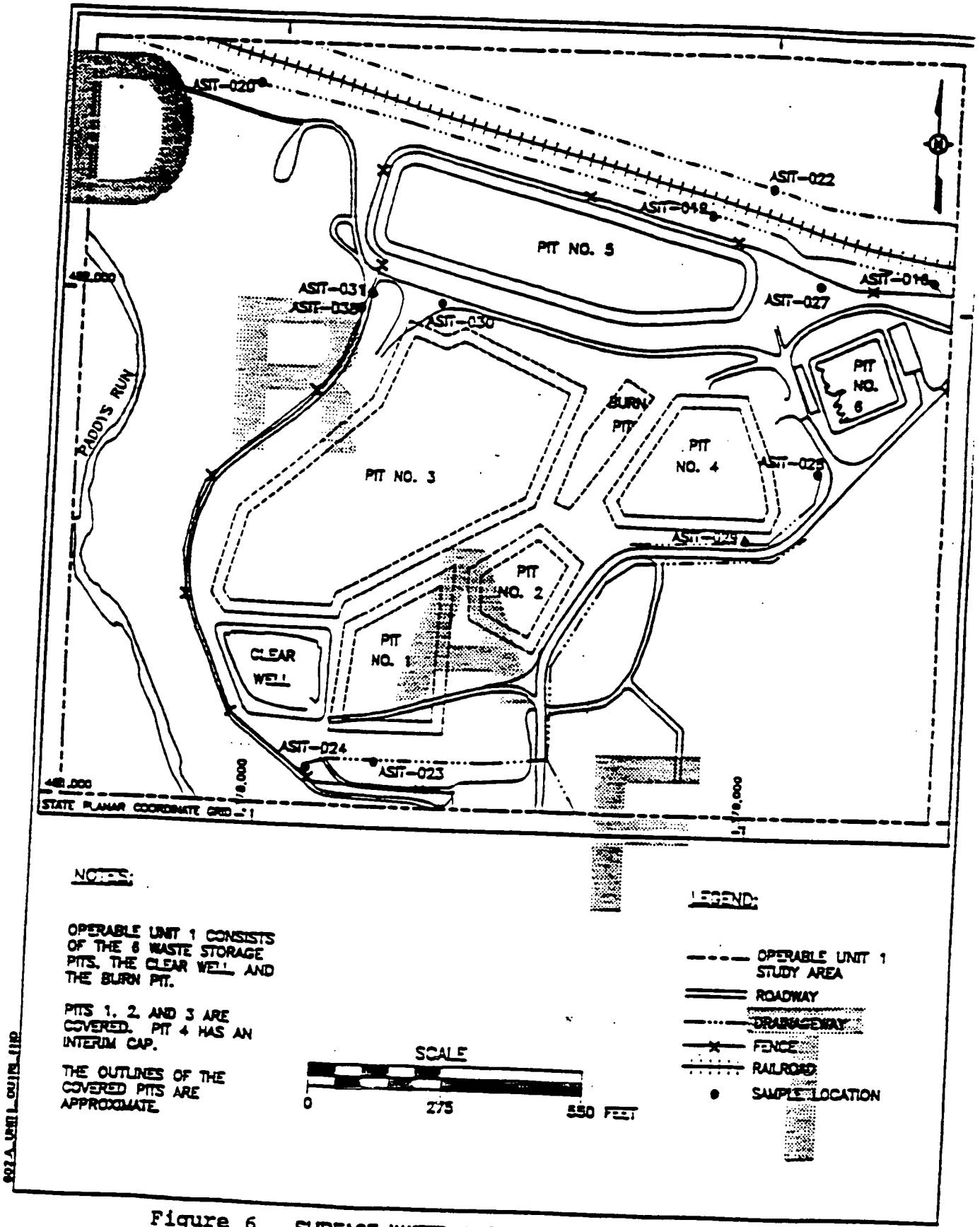

Figure 6 SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS

2.4 Environmental Air Samples

The Environmental Monitoring Program at FMPC includes three air particulate sampling locations in the vicinity of the Waste Pit Area: AMS 1, 6, and 7 (Figure 7). They are indicative of the closest possible off-site receptors for inhalation. The average airborne concentrations for 1989 are given in Appendix B. Average meteorological data indicate that AMS 1 is downwind of the WPA. However, concentrations are not higher at this location. AMS 1 is closer to the production area and could be influenced by airborne effluent from that direction. Variation in the isotopic mix of air concentrations suggests different sources. The average yearly concentrations of the various isotopes are compared below for AMS 1, 6, and 7.

Average Airborne Concentrations during 1989
(E-16 uCi/ml)

Isotope	AMS 1	AMS 6	AMS 7
Tc-99	<1.80	<1.60	1.70
U-234	0.86	1.20	0.77
U-235	0.06	0.06	0.03
U-236	0.024	0.027	0.013
U-238	1.60	1.50	0.83
Ra-226	0.098	0.16	0.20
Ra-228	<0.10	0.095	0.13
Sr-90	0.12	<1.6	0.13
Th-228	<0.073	0.11	<0.76
Th-230	0.088	<0.095	<0.078
Th-232	<0.073	<0.095	<0.076

Because of its radiological properties, the technetium-99 noted at AMS 7 is an insignificant source of radiation dose in comparison to the other radionuclides present. All or most of the strontium-90 is a fission product which is ubiquitous through world-wide fallout. It will be further described in Section 3; however, the concentrations lead to relatively low effective dose equivalents that amount to less than one mRem/yr.

The isotopic ratios can be compared for surface and airborne contaminants to observe the extent of agreement. Agreement could mean that airborne activity is due to entrainment of surface activity. Appendix D provides such a comparison. Comparison of the airborne and surface ratios show sufficient agreement and that the airborne concentrations are generally representative of entrained surface contaminants.

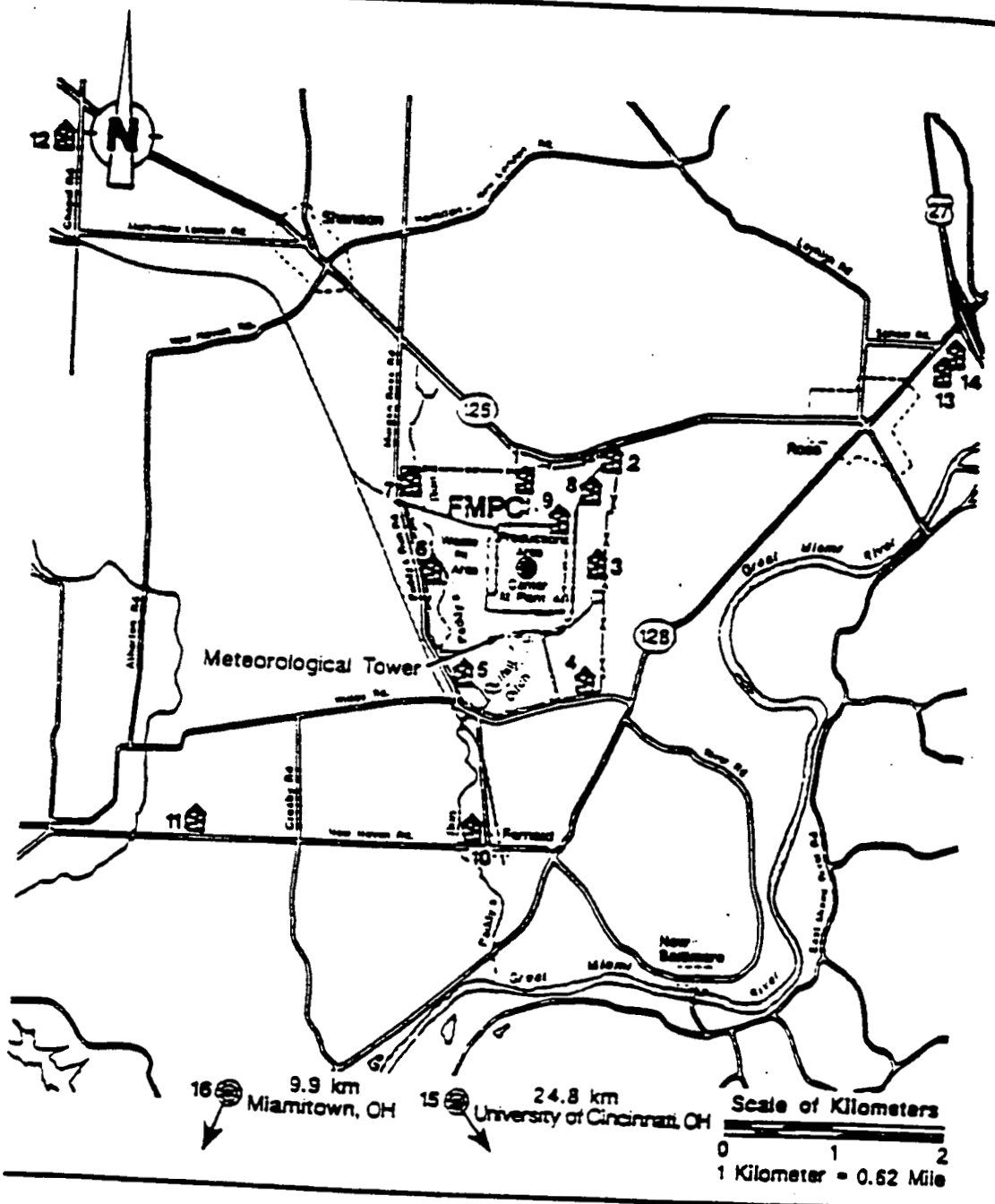

Figure 7 Air Monitoring Locations

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2.5 Pathways Assessment

The purpose of this RSE is to determine if surface contamination warrants interim removal actions to reduce existing exposure and to abate any release of contaminants to the environment. Only the airborne inhalation path is considered as a source of exposure to off-site residents. Exposure to contamination which is deposited downwind is expected to have little or no consequence in the near term based upon the observed airborne concentrations. Similarly, ingestion of food products, that have been exposed to downwind deposition, is expected to be of minimal consequence.

Another pathway that will be considered is occupational exposure to the FMPC employee who could be exposed through inhalation and external radiation. Employees have the greatest potential for exposure. If this risk is relatively low, there is less justification for a removal action. Discussion with maintenance personnel showed that a conservative estimate of worker occupancy is 10 hours per week.

This RSE does not include evaluation of pathways associated with contaminant migration through stormwater runoff. DOE is currently undertaking a separate removal action in the WPA to address contaminated stormwater runoff control. This RSE also does not include consideration of exposure from the relatively larger inventories contained within the Waste Pits. These issues, as well as other significant sources of exposure, are addressed in the RI/FS along with candidate remedial actions.

3.0 Evaluation of The Magnitude of the Potential Threat

The source term that has been developed permits an estimate of current risks from exposed contamination in the WPA. Average air sample concentrations from the three closest sampling locations are used to quantify environmental exposure. Occupational inhalation and external exposure is estimated from surface soil and sediment at the area with the highest concentrations of contaminants. Calculations for the results contained in this section used average values for contaminant concentrations. The uncertainty of the averages for soil and sediment samples (Section 2.3) and those for air sample concentrations (Appendix B) must be recognized.

3.1 Environmental Exposure to Airborne Contaminants

Air sample concentrations are given in Appendix B. Appendix C.1 shows the dose and associated risk calculations due to those airborne concentrations. The maximum committed effective dose equivalent (CEDE), through inhalation by a resident at the boundary of the WPA, is estimated to be less than 0.4 mRem/yr. The 70 year cancer risk associated with this CEDE is less than 1.4E-05. This value is much less that the EPA NESHAP limit of 10 mRem/yr, which has an associated 70 year cancer risk of 3.5E-04.

3.2 Occupational Exposure.

The two means of occupational exposure are inhalation of entrained surface activity and external exposure while standing on the contaminated surface. It is assumed that work is limited to the area of highest radioactive concentrations. It is also assumed that the worker is exposed for 10 hr/wk, 50 wk/yr, for a 50 year employment period.

3.2.1 Inhalation Exposure

Appendix C.2.1 shows the dose calculations for occupational inhalation exposure. The CEDE and risk due to inhalation is estimated to be:

	CEDE	Risk
Average	10 mRem/yr.	2.5E-04

and with 95% confidence

Less than	39 mRem/yr.	9.8E-04

3.2.2 External Exposure

Appendix C.2.2 shows calculations for the occupational radiation dose due to external exposure. The CEDE and risk is estimated to be:

	CEDE	Risk
Average	11 mRem/yr.	2.8E-04

and with 95% confidence

Less than	44 mRem/yr	1.1E-03

3.2.3 Combined Dose and Risk

The combined committed effective dose equivalent for the occupational inhalation and external exposure yields an average estimate of 21 mRem/yr. This is relatively low in comparison to the occupational dose limit of 5,000 mRem/yr, from DOE Order 5480.11.

The cancer risk associated with less than 21 mRem/yr., extended to a 50 year period, is less than 5.3E-04.

With 95% confidence, the CEDE is less than 83 mRem/yr. and the cancer risk is less than 2.1E-03.

4.0 Assessment of the Need for a Removal Action

Consistent with Section 40 CFR 300.410 of the National Contingency Plan, the Department of Energy (DOE) shall determine the appropriateness of a removal action. Eight factors to be considered in this determination are listed in 40 CFR 300.415 (b)(2). The following apply specifically to the concentrations of contaminants occurring in the waste pit area:

40 CFR 300.415 (b)(2)(i)

Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants.

40 CFR 300.415 (b)(2)(iv)

High levels of hazardous substances or pollutants or contaminants in soils largely at or near the surface, that may pose a threat of release.

40 CFR 300.415 (b)(2)(v)

Weather conditions that may cause hazardous substances or pollutants or contaminants to migrate or be released.

40 CFR 300.415 (b)(2)(vii)

The availability of other appropriate federal or state response mechanisms to respond to the release.

These factors are considered appropriate as a result of the concentrations of contaminants in the soils in the waste pit area. However, the extent of risk is minimal due to the present stable surface conditions, **the access controls in place, and the worker protection requirements.**

5.0 Appropriateness of a Response

If a planning period of less than six months exists prior to initiation of a response action, DOE will issue an Action Memorandum. The Action Memorandum will describe the selected response and provide supporting documentation for the decision.

If it is determined that there is a planning period greater than six months before a response is initiated, DOE will issue an Engineering Evaluation/Cost Analysis (EE/CA) Approval Memorandum. This memorandum is to be used to document the threat of public health and the environment and to evaluate viable alternative response actions. It will also serve as a decision document to be included in the Administrative Record.

An evaluation of the site characterization information in the Waste Pit Area indicates only a minor risk associatied with the existing soil contamination. The FMPC is currently on the National Priorities List and is in the RI/FS process. The final remedial action will address the means of removing or further stabilizing the contaminated soil and sediment in the Waste Pit Area.

APPENDICES

APPENDIX A

SURFACE SOIL, SEDIMENTS

APPENDIX A.1

PIT 4-6 AREA

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Table A.1.1 C.I.S. SEDIMENT SAMPLES IN THE PIT 4-6 AREA (pCi/g)

Sample Number	U-238	U-235	U-234	Th-232	Th-230	Th-228	Ra-226
28-002	111±1	2.4±0.2	19±1	0.2±0.1	0.9±0.1	0.3±0.1	< 3.0
28-007	728±9	12±1	121±4	0.8±0.2	9.0±0.6	1.7±0.3	< 0.4
28-008	761±9	26±2	133±4	0.1±0.1	0.1±0.1	0.2±0.1	< 3.2
28-010	338±4	14±1	62±2	1.1±0.2	7.6±0.5	2.6±0.3	< 2.3
28-011	446±6	18±1	85±2	< 0.1	0.9±0.1	0.2±0.1	< 5.0
36-001	480±6	27±1	89±3	0.6±0.1	4.0±0.3	1.0±0.2	< 1.8
36-002	746±8	29±2	131±4	0.6±0.1	5.1±0.4	1.1±0.2	< 4.2
36-003	369±5	9.4±0.7	71±2	0.1±0.1	0.5±0.2	0.2±0.1	< 5.3
36-004	696±7	33±2	126±3	0.5±0.1	6.1±0.4	1.3±0.2	< 4.2
36-006	696±7	33±2	126±3	0.3±0.1	4.4±0.3	0.7±0.1	<2.9

Sample locations are on the following figure.

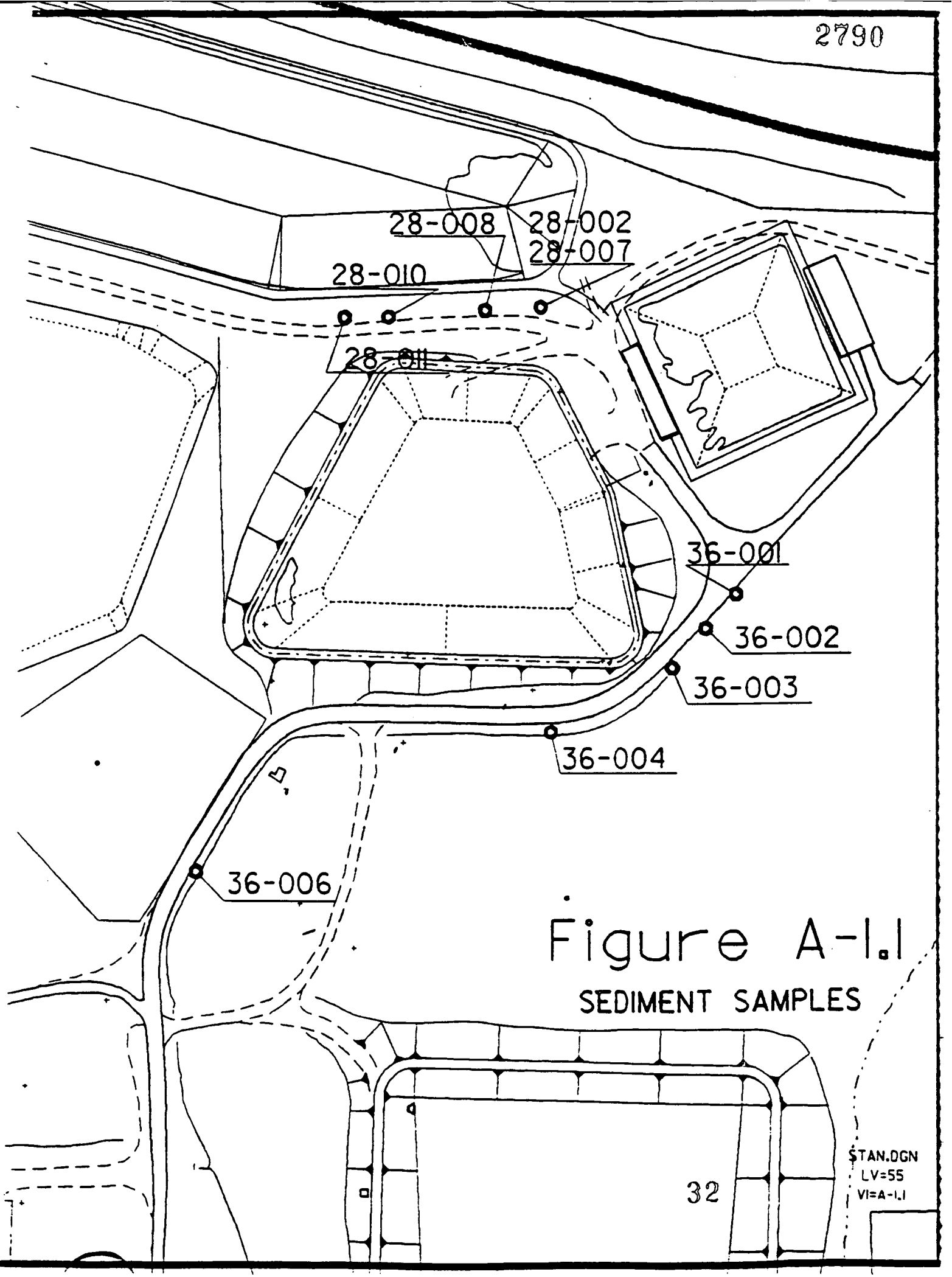

Figure A-1.1

SEDIMENT SAMPLES

Table A.1.2 C.I.S. SURFACE SOIL SAMPLES IN THE PIT 4-6 AREA (pCi/g)

Sample Number	U-238	U-235	U-234	Th-232	Th-230	Th-228	Ra-226
46-427	738±12	11±1	127±5	1.6±0.2	13±1	2.8±0.3	< 3.4
46-428	154±2	2.9±0.3	33±1	1.7±0.3	24±1	2.5±0.3	2.8±1.0
46-430	287±6	4.2±0.9	54±3	1.0±0.2	5.4±0.4	1.3±0.2	< 2.8
46-432	342±4	5.1±0.5	57±2	0.1±0.1	0.3±0.1	0.1±0.1	< 5.9
46-434	15±1	0.6±0.1	14±1	0.8±0.1	146±1	0.7±0.1	< 4.9
46-435	639±12	10±1	109±5	2.3±0.6	18±2	4.8±0.8	< 6.5
46-444	238±3	5.2±0.4	47±1	< 0.1	0.1±0.1	< 0.1	1.1±0.9
46-446	95±1	1.6±0.2	21±1	1.7±0.4	13±1	1.4±0.4	1.1±0.6
46-504	1500±20	25±3	241±10	0.2±0.1	0.1±0.1	< 0.2	< 2.7
46-623	157±2	11±1	155±2	31±7	972±38	48±10	27±2
46-474	293±4	3.4±0.5	43±2	0.2±0.2	1.4±0.4	0.2±0.2	< 5.7
Average	491	93	2.4	59	3.2		< 4.5
Std. Dev.	334		55	7.0	212	9.8	5.3

Average Concentrations for Soil and Sediment

Average	468	14	89	2.1	59	3.4	4.6
Std. Dev.	341	11	56	6.6	212	10.3	5.4

Less than detectible limits were included in the average concentration calculations.

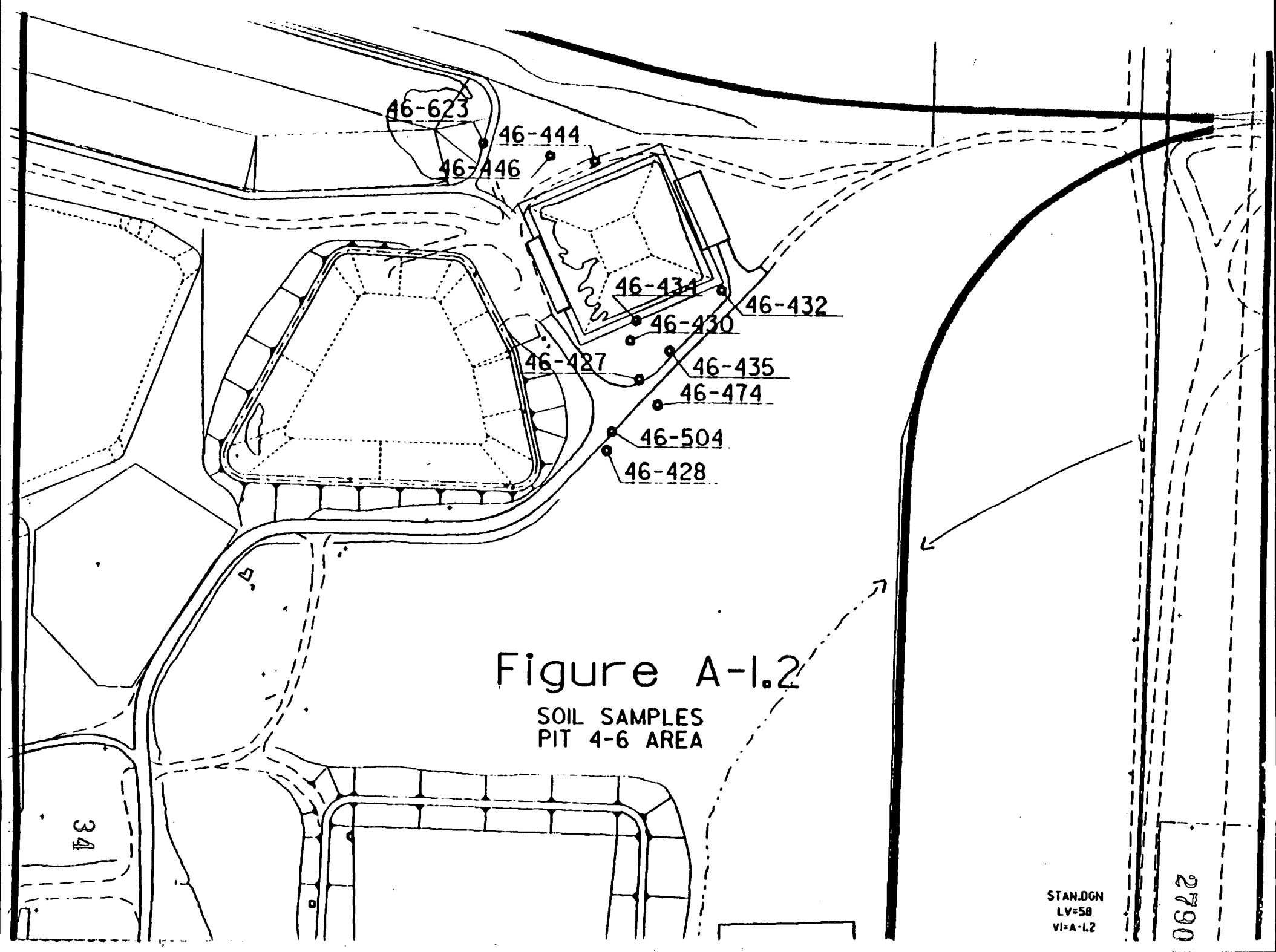

Figure A-1.2

SOIL SAMPLES
PIT 4-6 AREA

APPENDIX A.2

SOUTH EAST OF PIT 2

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APPENDIX A.2 C.I.S. SURFACE SOIL AND SEDIMENT SAMPLES (pCi/g)

Sample Number	U-238	U-235	U-234	Th-232	Th-230	Th-228	Ra-226
Sediment Samples							
36-006	696±7	33±2	126±2	0.3±0.1	4.4±0.3	0.7±0.1	< 2.9
Soil Samples							
46-478	406±5	5.8±0.6	73±2	< 0.1	0.1±0.1	< 0.1	2.3±1.0
46-488	60±1	1.0±0.1	18±1	3.0±0.3	32±1	5.4±0.4	3.4±1.7
46-495	753±12	10±1	123±5	2.4±0.3	46±1	11±1	< 8.8
46-500	28±1	0.6±0.1	12±1	0.2±0.1	4.0±0.3	0.3±0.1	------
46-456	27±1	0.5±0.2	11±1	< 0.1	0.9±0.2	0.1±0.1	2.3±0.8
Average	328	8.5	61	1.0	15	2.9	3.9
Std. Dev.	339	12.6	55	1.3	20	4.5	2.8

The above averages and standard deviations include values from both the soil and sediment.

Sample locations are shown on the following figure.

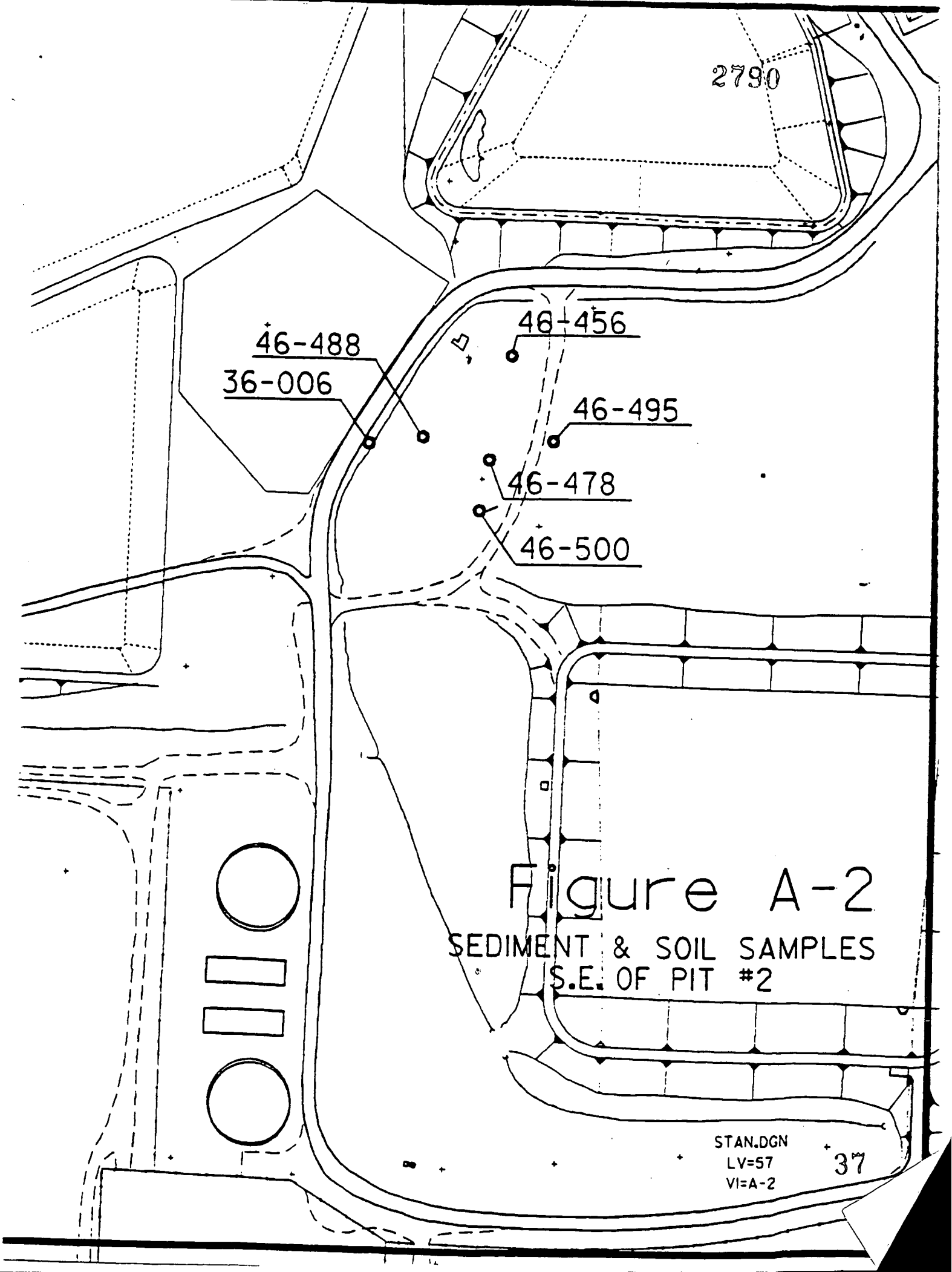

Figure A-2

SEDIMENT & SOIL SAMPLES
S.E. OF PIT #2

APPENDIX A.3

EAST OF THE WASTE PITS AREA

APPENDIX A.3 C.I.S. SURFACE SOIL SAMPLES EAST OF THE WASTE PIT AREA (pCi/g)

Sample Number	U-238	U-235	U-234	Th-232	Th-230	Th-228	Ra-228	Ra-226
46-407	710±6	16±1	130±3	0.3±0.1	1.1±0.1	0.2±0.1	---	< 3.7
46-409	303±3	6.3±0.5	57±1	6.2±0.5	18±1	17±1	---	6.8±1.3
46-457	113±2	1.8±0.2	20±1	< 0.1	0.5±0.1	0.4±0.1	---	< 4.8
46-518	251±3	4.8±0.5	40±1	0.1±0.1	0.2±0.1	0.1±0.1	---	< 5.5
46-519	302±5	4.9±0.7	49±2	0.1±0.1	0.4±0.2	0.4±0.2	---	< 4.9
46-037	157±2	2.1±0.3	28±1	0.8±0.4	2.4±0.5	0.8±0.4	---	0.8±0.5
46-045	23±1	0.4±0.1	4.6±0.3	0.6±0.2	1.6±0.2	0.7±0.2	---	0.9±0.4
46-142	4.8±0.3	0.2±0.1	3.1±0.2	1.0±0.2	6.3±0.4	1.1±0.2	---	6.1±1.0
46-358	95±1	1.7±0.2	28±1	1.4±0.4	7.4±0.9	1.7±0.5	---	1.1±0.5
46-360	45±1	1.7±0.2	35±1	38±2	17±1	35±2	---	<3.0
46-059	280±4	5.7±0.5	55±2	1.4±0.3	11±1	2.4±0.5	---	1.1±0.7
46-175	5.8±0.4	0.2±0.1	4.1±0.4	2.3±0.6	9.4±1.2	2.4±0.5	---	3.4±2.6
46-450	583±5	33±1	153±2	0.6±0.1	0.5±0.1	0.5±0.1	---	24.7
46-591	6.2±0.5	0.2±0.1	3.3±0.4	0.1±0.1	0.7±0.1	0.1±0.1	---	17.4
46-362	304±4	4.7±0.5	57±2	1.5±0.3	6.4±0.5	3.4±0.4	---	2.8±1.3
46-461	194±2	4.5±0.4	47±1	2.9±0.5	4.5±0.6	3.4±0.6	---	<2.5
46-588	3.6±0.2	0.1±0.1	2.1±0.2	<0.3	1.1±0.6	<0.4	---	9.4±1.0

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Figure A-3

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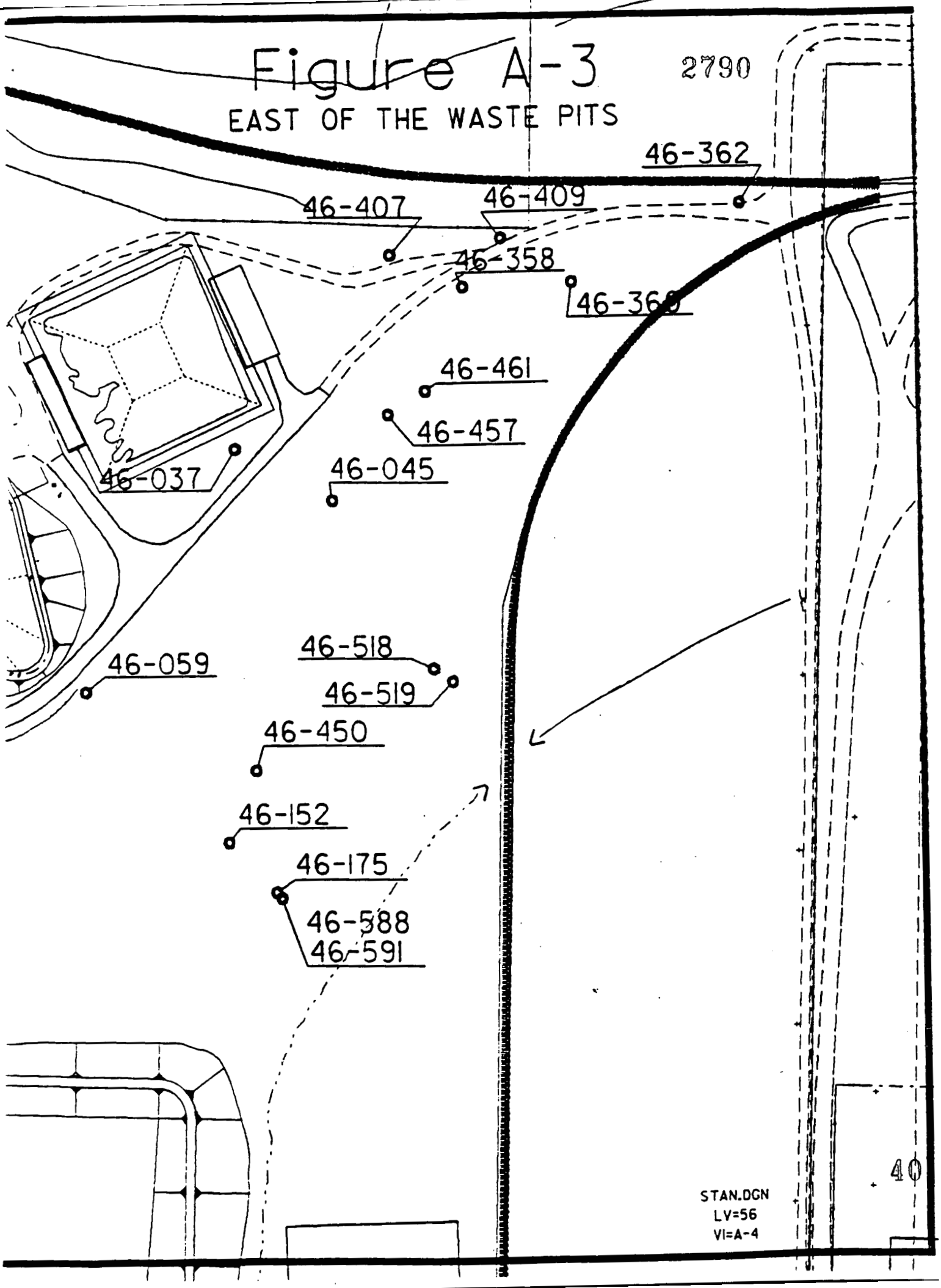
EAST OF THE WASTE PITS



APPENDIX B

ENVIRONMENTAL AIR SAMPLES

Table B.1 Radionuclides in Air, 1989 (page 1 of 2)
Concentration of Radionuclides at Air Monitoring Stations in $\mu Ci/m^3 x10^{-12}$

Radionuclide	AMS 1	AMS 2	AMS 3	AMS 4	AMS 5	AMS 6
Sr-90	12±6.2	33±7.8		24±6.3	NA	52±9.5
Tc-99	< 180	< 120	160±110	< 160	< 160	< 160
Ru-106[f]	< 11000	< 9500	< 11000	< 9700	< 9400	< 9500
Cs-137	< 100	< 94	< 110	< 97	< 94	< 95
Ra-226	9.8±1.9	15±2.9	< 0.53	1.0±0.23	8.0±1.7	16±3.1
Ra-228	< 10	< 9.4	< 11	< 9.7	< 9.4	9.5±4.0
Th-228	< 7.3	< 8.0	< 11	< 9.7	8.3±6.0	11±7.5
Th-230	8.8±5.8	10±6.5	< 11	< 9.7	< 8.0	< 9.5
Th-232	< 7.3	< 8.0	< 11	< 9.7	< 8.0	< 9.5
Np-237						
Pu-238	< 2.1	< 2.0	3.0±2.1	< 2.5	< 2.7	< 2.6
Pu-239	0.22±0.0023	0.23±0.0023	0.49±0.0033	0.20±0.0021	0.20±0.0020	0.20±0.0018
Pu-240	.064±.00083	.065±.00086	.13±.0012	.060±.00077	.057±.00064	.060±.00065
Pu-239/240						
Pu-241	0.85±0.048	0.90±0.044	2.0±0.055	0.77±0.055	0.69±0.024	0.68±0.034
Pu-242(E-06)	37±2.1	37±9.1	71±2.1	21±1.9	37±1.5	
U-234	86±31	110±37	200±72	76±27	43±15	120±41
U-235	6.0±0.17	7.3±0.21	13±0.38	4.0±0.11	4.5±0.13	6.0±0.17
U-236	2.4±0.36	3.6±0.55	8.4±1.3	1.6±0.24	1.8±0.27	2.7±0.41
U-238	150±0.03	190±0.036	360±0.07	100±0.02	100±0.02	160±0.03
U-Total	259±96	300±37	580±72	180±27	160±15	280±41

Blank spaces indicate those analyses were not performed.

Table B.1 Radionuclides in Air, 1989 (page 2 of 2)
Concentration of Radionuclides at Air Monitoring Stations in $\mu Ci/m^3 x 10^{-12}$

Radionuclide	AMS 7	AMS 8	AMS 9	AMS 10	AMS 11	AMS 12
Sr-90	7.7±6.0	36±7.2	18±7.9	8.5±3.1	7.1±2.9	57±6.9
Tc-99	170±99	< 160	330±120	< 2.4	< 1.9	< 2.1
Ru-106	< 10000	< 9200	< 10000	< 1600	< 1400	< 1600
Cs-137	< 100	< 92	< 100	< 180	< 160	< 170
Ra-226	20±3.6	< 0.46	< 0.52	55±9.0	39±6.6	39±6.6
Ra-228	13±4.5	< 9.2	< 10	< 20	< 24	< 13
Th-228	< 7.6	< 19	< 13	13±4.0	4.9±1.4	12±3.4
Th-230	< 7.6	< 19	< 13	13±4.0	4.0±1.4	12±3.4
Th-232	< 7.6	< 19	< 13	< 2.2	< 1.2	< 1.7
Np-237				0.22±0.16	< 0.21	< 0.21
Pu-238	5.5±2.6	< 7.8	< 3.2	< 0.17	< 0.25	< 0.19
Pu-239	0.14±0.0016	0.40±0.0029	1.4±0.013			
Pu-240	0.044±.00046	0.11±0.0010	0.23±0.0024			
Pu-239/240				< 0.16	< 0.24	< 0.17
Pu-241	0.39±0.021	1.6±0.033	3.5±0.054			
Pu-242(E-06)	30±1.4	81±1.6	200±4.1			
U-234	77±27	69±25	530±190	37±13	20±6.9	16±5.7
U-235	3.3±0.09	13±0.38	35±1.0	2.4±0.07	1.3±0.04	1.1±0.03
U-236	1.3±0.19	6.4±0.98	20±3.0	1.1±0.17	0.60±0.09	0.49±0.07
U-238	83±0.02	370±0.07	940±0.18	63±0.01	34±0.01	28±0.01
U-Total	160±27	460±25	1500±190	100±13	56±6.9	45±5.7

Blank spaces indicate those analyses were not performed.

APPENDIX C

RISK ASSESSMENT CALCULATIONS

C.1 Environmental Exposure to Airborne Contaminants

Average concentrations of principle radionuclides at air sample locations AMS 1, 6 and 7, are compared to concentrations in DOE order 5400.5[3] which are modelled to estimate an annual maximum committed effective dose equivalent (CEDE) of 100 mRem/yr. The derived CEDEs are as shown.

Isotopes	Avg.Airborne Concen. (uCi/ml)	5400.5 DCG (uCi/ml	CEDE (mRem/yr)
U-238	1.3E-16	1.0E-13	1.3E-01
U-234	9.4E-17	9.0E-14	1.0E-01
Ra-226	1.5E-17	1.0E-12	1.5E-03
Th-228	<8.6E-18	4.0E-14	<2.2E-02
Th-230	<8.6E-18	5.0E-14	<1.7E-02
Th-232	<8.1E-18	1.0E-14	<8.1E-02
U-235	5.1E-18	1.0E-13	5.1E-03
			<3.6E-01

The risk can be estimated from inspection of the EPA H.E.A.S. Slope Factors Tables for uranium isotopes. The calculated risk coefficient for all cancer incidence (including non-fatal cancer) is 500 E-06 per Rem. If one uses a value of < 0.4 mRem/yr the 70 year cancer risk is calculated to be:

$$<0.4 \text{ mRem/yr} \times 70 \text{ yr} \times 5.0 \times 10^{-7}/\text{mRem} = < 1.4\text{E-}05$$

C.2 Occupational Exposure

C.2.1 Inhalation exposure

The highest surface concentrations were identified in the Pit 4-6 area. The 1989 Environmental Monitoring Report[1] showed environmental airborne dust to be approximately 35 ug/m^3. A more conservative estimate can be based upon relatively dusty conditions by using the RESRAD default value of 200 ug/m^3.

---

[3]DOE Order 5400.5, "Radiation Protection of the Public and the Environment," February 8, 1990.

Airborne concentrations can be estimated by:

X pCi/g soil x 200 ug/m^3 x 10^{-6}g/ug x $10^{-6}m^3$/ml x 10^{-6} uCi/pCi

= uCi/ml airborne

or

X pCi/g soil x 2 x 10^{-16} = uCi/ml airborne

Based upon average concentrations for Pits 4-6 surface soil samples, the following airborne concentrations can be calculated.

Isotope	Soil (pCi/g)	Airborne (uCi/ml)
U-238	468	9.4×10^{-14}
U-235	14	2.8×10^{-15}
U-234	89	1.8×10^{-14}
Th-232	2.1	4.2×10^{-16}
Th-230	59	1.2×10^{-14}
Th-228	3.4	6.8×10^{-16}
Ra-226	4.6	9.2×10^{-16}

These concentrations can then be compared to the model in DOE Order 5480.11[2] which provide airborne concentrations that are equivalent to a maximum CEDE for occupational exposure of 5 Rem/yr.

Isotope	Estimated Airborne (uCi/ml)	5480.11 DCG (uCi/ml)	CEDE (mRem/yr.)
U-238	9.4×10^{-14}	2.0×10^{-11}	24.0
U-235	2.8×10^{-15}	2.0×10^{-11}	0.7
U-234	1.8×10^{-14}	2.0×10^{-11}	4.5
Th-232	4.2×10^{-16}	1.0×10^{-12}	2.1
Th-230	1.2×10^{-14}	7.0×10^{-12}	8.6
Th-228	6.8×10^{-16}	7.0×10^{-12}	0.5
Ra-226	9.2×10^{-16}	3.0×10^{-10}	0.02
			40.0

The CEDE of approximately 40 mRem/yr is low in comparison to occupational exposure limits of 5 Rem/yr. Further, discussion with maintenance supervision shows that the maximum potential work in the WPA amounts to ten hours per week. The best estimate becomes a CEDE of 10 mRem/yr.

Using the same risk basis as in C.1, for a 50 year period, then:

10 mRem/yr. x 50 yr. x 5.0 x 10^{-7}/mRem = 2.5E-04

Since this estimate is based upon very variable sample concentrations, assessment based upon the statistics of the measurement is in order. If the observed average concentrations have two standard deviations added, that value can be used to calculate a higher CEDE. Then there is 95% confidence that the CEDE is lower. That computation, for an occupancy of 10 hrs/wk, yields:

Maximum CEDE with 95% Confidence
Occupational Inhalation Exposure
(mRem/yr.)

U-238	14.5
U-235	0.5
U-234	2.6
Th-232	3.8
Th-230	16.6
Th-228	0.9
Ra-226	0.02
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The 50 yr. risk becomes 9.8E-04.

C.2.2 External occupational exposure

To assess this exposure path, the RES RAD[1] model is used with a change in the occupancy factor. While 0.60 (60%) is used to assess environmental exposure, this analysis uses 0.06. This is based upon exposure for 10 hours per week and 50 weeks per year.

Using the RES RAD dose conversion factors and assuming a soil density of 1.8 g/cm^3,

Isotope	Soil Conc. (pCi/g)	Volume Conc. (pCi/cm^3)	mRem/yr per pCi/cm^3)	Effective Dose Equivalent (mRem/yr)
U-238	468	842	6.97E-02	3.5E+00
U-235	14	25	4.9E-01	7.4E-01
U-234	89	160	6.97E-04	6.7E-03
Th-232	2.1	3.8	6.04E-04	1.4E-04
Th-230	59	106	1.03E-03	6.6E-03
Th-228	3.4	6.1	7.36E+00	2.7E+00
Ra-226	4.6	8.3	8.56E+00	4.3E+00
				11.3

Based upon the estimate of 11 mRem/yr., and the prior method, the risk becomes:

$$11 \text{ mRem/yr} \times 50 \text{ yr} \times 5.0 \times 10^{-7}/\text{mRem} = 2.8\text{E-}04.$$

Inspecting the statistics associated with the degree of uncertainty associated with the average soil concentrations, the following represents the upper limit at 95% confidence.

Maximum CEDE with 95% Confidence
External Occupational Exposure
(mRem/Yr.)

U-238	8.7E+00
U-235	1.9E+00
U-234	1.5E-02
Th-232	1.0E-03
Th-230	5.2E-03
Th-228	1.9E+01
Ra-226	1.4E+01
	44

The 50 year risk becomes 1.1E-03. **Although 50 years is used for conservatism, occupational exposure will cease at completion of final remediation which is estimated to be a 5 to 10 year period.**

APPENDIX D

COMPARISON OF SURFACE AND AIRBORNE CONTAMINANTS

The isotopic ratios can be compared for surface and airborne contaminants to observe the extent of agreement. Agreement could mean that airborne activity is due to entrainment of surface activity. The following comparisons are based on normalizing isotopic concentrations to uranium-238. These are also weighted by the number of samples analyzed. That normalization for surface contamination shows the following.

Isotopic Ratios Among Surface Contaminants
(normalized to uranium-238)

U-238	1.00
U-235	2.9E-02
U-234	2.0E-01
Th-232	6.8E-03
Th-230	8.6E-02
Th-228	9.7E-03
Ra-226	1.7E-02

The earlier summary of soil data (Section 2.3) shows considerable variation among the samples.

The same comparison can be made among the three air sampling locations.

Isotopic Ratios Among Airborne Contaminants
(normalized to uranium-238)

Isotope	AMS 1	AMS 6	AMS 7
U-238	1.00	1.00	1.00
U-235	4.0E-02	3.8E-02	4.0E-02
U-234	5.7E-01	7.5E-01	9.3E-01
Th-232	4.9E-02	5.9E-02	9.2E-02
Th-230	5.9E-02	5.9E-02	9.2E-02
Th-228	4.9E-02	6.9E-02	9.2E-02
Ra-226	6.5E-02	1.0E-01	2.4E-01

The ratios among the air sampling locations are relatively the same given the statistics associated with analysis for low airborne concentrations.

Comparison of the airborne and surface ratios show that there is sufficient agreement and that, within the variance associated with average soil concentrations, the airborne concentrations are representative of entrained surface contaminants.

1."FMPC Site Environmental Report for Calendar Year 1989," (FMPC-2200) Westinghouse Materials Co., of Ohio, U.S. Department of Energy, June 25, 1990 (draft).

2.DOE order 5480.11 "Radiation Protection for Occupational Workers," December 21, 1988.